Factors Affecting Birthweight Decline in Recent Japan Based on Birth Certificates

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Abstract

Background:

Birthweight is declining consistently for more than 30 years in Japan. Rapid rise in low birth weight infant counts one of the worst among OECD countries.

Objective: To add new information for clarifying the factors associated with the decline in birthweight in Japan.

Methods: Government vital statistics records were used under permission. 40,968,266 birth records born between 1980 and 2004 were analyzed. Multivariable linear regression analysis was used to examine whether the decline in the birthweight could be explained by obstetrical variables such as gestational age and plurality.

Results: From 1980 to 2004, we observed a decline in mean birthweight with yearly effect of -8.07g, which got steeper after 1985 and persisted until 1999, and plateaued thereafter. After adjustment for gestational age, neonatal gender, birth order, plurality, father age, yearly effect became -5.13g, between 1980 and 2004.

Conclusion Recent decreases in birthweight among Japanese neonates were not fully explained by trends of gestational age, sex, birth order, plurality and father age. We should consider additional factors such as pre-pregnant maternal BMI and maternal diet.

Purpose

Brithweight is declining consistently for more than 30 years in Japan. Mean birthweight of Japan is generally small. The value counted 3000g in 2018 (3050g in baby boys and 2960g in baby girls)[1]. In many countries mean birthweight shows larger value, for example, 3455g of USA in 2003[2], 3316g of England and Wales in 2012[3], 3322g of Canada in 2018[4] and 3200g of Korea in 2016[5].

Proportion of low birth weight (LBW) infants in Japan, defined as lower than 2500 g, are on the rise[6, 7] Proportion of LBW in Japan is high and rapid in increase. It counted 6.3% in 1990 and 9.4% in 2018, compared to Canada (from 5.5% to 6.5%), UK (from 6.7% to 6.9%) and USA (from 7.2% to 8.3%) in the same time period, and in Korea from 2.6% (1993) to 6.2% (2018).[8] Rapid increase counts as the fifth worst among OECD countries.[9]

In the United States, mean birthweight increased until the 1990s.[10-12] Similar trends occurred in Canada,[13-15] the United Kingdom,[16, 17] Scandinavia [18-20] . According to a recent report, U.S. national data show that mean birth weight is declining thereafter. [21] Some studies found out that birthweight was declining over recent years also in Korea [5, 22] and Sweden [23].

The incidence of LBW has important public health issue because of its association with increased metabolic syndrome during adulthood, developmental delay, longer hospital stay of neonates with increased burden of health care costs. In adult life, LBW predisposes to chronic diseases and mortality. [7] The overall aim of the present study was to determine the factors associated with birthweight decline for a few decades in Japan using vital statistic data from the Ministry or Health, Labour and Welfare.

Subjects And Methods

In Japan, birth certificates are systematically stored on electric data files by the Ministry of Health, Labor and Welfare (MHLW). These certificates are filled in by obstetric clinicians or midwives following obstetric recording in the hospitals or clinics, and are filed in the city health department and changed into computerized files at the MHLW. This database is anonymous and includes information relating to neonate gender, birth weight, birth length, gestational age (GA), plurality, parity, ages of father and mother and birthplace.

Under permission from the Statistics and Information Department, the Minister's Secretariat, the Ministry of Health, Labour and Welfare, a total of 40,968,279 birth certificate files in the database from newborns from 1980 to 2004 were obtained. We used the data of these period because mean birth weight showed clear decline (Figure1).

For the birthweight, from 1980 to 1994, we added 50 grams to the recorded birthweight in the database to obtain the most probable expected values, because birthweight was recorded every 100 grams which does not exceed actual birthweight value. For GA during the same period, 0.5 weeks were added to the recorded GA, because GA was rounded down to nearest integer. From 1995 to 2004, GA was recorded as complete weeks and additional days, which were divided by seven and added to value of the complete weeks.

The figures were in exact values in birthweight, gestational age, age of fathers and mothers, prefectural number and delivery number. For plurality, 1 stands for singletons and 2 stands for multiple births. For gender, 1 stands for male and 2 stands for female.

Within the variables shown in the Table1, those with higher correlation were calculated as explanatory variable for birthweight, which were gender, father age, mother age, fetus number (or plurality), the main occupation of a household, birth ranking, birth place, GA, and number of times of parity. Mother age showed smaller correlation with birthweight at linear analysis.

A value of $P < 0.05$ was considered statistically significant. We performed all analyses using SAS version 9.1 (SAS Institute, Cary, NC).

Results

From 1980 to 2004, we observed a decrease in birth weight, which got steeper after 1985, persisted until 1999, and plateaued thereafter (Figure 2). Table1 shows overall correlations with birthweight (1980-2004), which was used to identify variables to be included in the regression analysis, along with means and standard deviations of variables in 1980 and 2004. From 1980 through 2004, birthweight, gestational age and delivery number decreased. Father age, mother age and plurality increased. The proportion of neonatal gender was almost stable and the proportion of multiple birth showed slight increase.

To clarify the factors affecting the decline in birthweight, we used a multiple linear regression analysis for all births from 1980-2004 (Table 2). From 1980 to 2004, we observed a decrease in birthweight with yearly effect of -8.07g/year. Adjusting for year, gender, father age, plurality, birthplace (prefectural number), gestational age and pregnancy number, yearly effect of BW was -5.13g/year. Gestational age accounted for most among the explanatory variables.

In the early period between 1980 and 1984, decrease in birthweight is relatively small. Crude yearly effect was -3.98 g/year and it became -0.53 g/year after adjustment. In the year period of 1985-1989, 1990-1994 and 1995-1999, decrease became steeper. Crude yearly effect was -8.50, -8.71 and -7.66 g/year respectively, which became

-3.66, -5.99 and -6.26 g/year after adjustment. In the late period between 2000 and 2004, decrease in birthweight got smaller. Crude yearly effect was -4.84 g/year and it became -2.87 g/year after adjustment. In the year period of 1980-1984, 1985-1989 and 2000-2004, gestational age accounted for most of the explained valuables, while in the year period of 1990-1994 and 1995-1999, gestational age accounted for near half of the explained valuables.

Discussion

From 1980 to 2004, mean birthweight decreased in Japan, especially between 1985 and 1999. The decline was not fully explained by adjustment for variables obtained from birth certificates.

Contrary to the end of the 20th century, birthweight began to decrease in USA[21] , Sweden[23], and South Korea[5, 22] .

Some studies are examining changes in birthweight among subgroups, for example, fill-term homogenous subset of low-risk mothers [2, 19, 21] . As expected, the decline in BW in present study was mainly caused by gestational age in the multivariable regression analysis. Through adjustment by all variables used in the multiple regression analysis, decrease in birthweight was 5.13 gr/year compared to crude decrease of 8.07g/year.

However, the observed decreases in gestational age did not entirely explain the declines in birthweight, which suggests that decline in birthweight occurs within specified weeks of gestation. Morisaki et al [24] pointed out that birthweight is decreasing regardless of gestational age in USA.

Strengths of this study is that the large nationally representative data are used, the form of which does not change for decades. We had information on potential factors associated with trends in birthweight.

One of the limitations of the present study is the estimation of GA. GA was filled in birth certificate by doctors or midwives in the hospitals or clinics. Some were based on the date of the last normal menstrual period and others were on early fetal ultrasound. This may impair the validity of our gestational age estimation.

Kramer [25] points out that gestational age calculated by the last menstrual period was shown to be fairly accurate among term births. Considering obstetrical practice, gestational length is affected by mode of delivery. Induction of labor also steadily increased by years in Japan [26] . Rates of cesarean deliveries based on national growth survey increased after 2000 [27]. These factors may cause the decline in gestational length. In US, gestational length decreased in neonates born both by vaginal delivery and by cesarean section. It also decreased both in induced labor and non-induced [10] .

Another limitation of the present study is the lack of data which may be associated with birthweight, such as maternal smoking status, pre-pregnancy weight and maternal diet during pregnancy. Maternal smoking restricts fetal growth restriction, and increases obstetrical complications, preterm births and stillbirths [15].

In Japan, proportion of pregnancy smoking was 5.0% in 1990, 10.0% in 2000 and 5.0% in 2010[28]. Moreover, in a recent survey on mothers and children aged 3 to 4 months, it was reported that LBW was significantly associated with maternal smoking. [29] Decrease in proportion of pregnancy smoking could be one of the causes for slowing of decrease in BW after 2000. In Japan, Health Promotion Law was enforced in 2002 and people were encouraged to quit smoking afterwards.

Information on maternal pre-pregnancy weight was not included in our data. BMI distribution among woman within reproductive age could be the proxy for pre-pregnant BMI. The prevalence of underweight has been increasing through decades in Japan in contrast to other countries [30] . In fact, the increase in birthweight in Sweden between 1992 and 2001 was explained by increases in maternal BMI in the same period along with decreases in maternal smoking [19]. In a hospital-based study in Canada, increase in birthweight was explained by increase in pre-pregnancy BMI, increase in gestational weight gain and decrease of prevalence of smoking during pregnancy [31]. In Sweden, from 1978 to 1992, birthweight increased within all maternal BMI categories after adjustment for gestational length, age, smoking habits, parity, and employment. After that, however, birthweight decreased among normal-weight women [23] . Our data did not include pre-pregnancy BMI. Besides, according to National Health and Nutrition Survey [32] , the proportion of women with BMI less than 18.5 whose age is between 20 and 39 years is increasing concomitantly with the decline in mean birthweight (Figure2). For the discussion of causality between maternal BMI and birthweight, further investigation is needed.

Our data also did not include maternal diet which may affect fetus growth. Rather, in Japan, through the results of National Health and Nutrition Survey [32] time trends of per capita calorie intake look like synchronized (Figure 3), however the causality is still unclear.

Other factors suggested for increasing low birth weight in Japan is the declining in adult height [33] . Increase in maternal age [34] is shown as a factor for decline in birthweight in Korea. In our study, maternal age did not show linear correlation to birthweight and could not be included as explanatory variable.

In this study of neonate born in Japan from 1980 to 2004, decreases in birthweight were not fully explained by factors included in the birth certificates. Decrease in gestational age only partially explained the decreasing birthweight. Birth size may influence not only short-time conditions but long-time prognosis [35] . Factors lowering birthweight, though not analyzed in the present study, could cause various health problems among children while they grow up. So follow-up study would be necessary to investigate what sequalae would derive from small birthweight neonates.

In conclusion, our study based on birth certificates shows that over the decades, birthweight of infants has been getting smaller. These findings may partially be explained by the decline in gestational age, considered to be derived from change in mode of delivery. Their clinical and social significance has yet to be determined.

List Of Abbreviations

OECD Organization for Economic Co-operation and Development

MHLW Ministry of Health, Labour and Welfare

GA gestational age

LBW low birth weight

Declarations

Ethics approval and consent to participate

The protocol of present study was approved by the Ethics Committee of National Institute of Public Health (approval number NIPH-IRBA #12010).

Consent for publication

Not applicable

Availability of data and materials

The data is provided from Statistics and Information Department of the Minister's Secretariat at the Ministry of Health, Labour and Welfare under permission of the Ministry. The data could be obtained if claimed and permitted.

Competing interests

None

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Authors' contributions

All authors have made a substantial contribution to the publication. NK contributed to literature search, study design, data collection, data interpretation and writing. CS contributed to data analysis, data interpretation and writing. HY contributed to data interpretation and writing. TY supervised the execution of the study, data interpretation and writing. NY supervised the design of the study, data interpretation and writing.

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Tables

Table 1. Correlation of variables with birthweight (1980-2004) and change in variables between 1980 and 2004

variables	units	correlation with birthweight		1980 (n=1569777)			2004 (n=1110721)		
		r^2	p-value	-	mean	SD	-	mean	SD
Birthweight	grams			-	3190	444	-	3014	441
Gestational age	weeks	0.2787	<0.0001	-	39.25	1.66	-	38.8578	2.096881
Father age	years of age	0.0007	<0.0001	-	30.33	4.21	-	31.68167	5.620598
Mother age	years of age	0.0003	<0.0001	-	27.62	3.75	-	29.69126	4.718895
Delivery number	including present birth	0.0078	<0.0001	-	1.78	0.83	-	1.690263	0.811955
Plurality	1=singleton 2=multiple birth	0.05	<0.0001	-	1.02	0.13	-	1.022649	0.148783
Neonate gender	1=boy 2=girl	0.0086	<0.0001	-	1.49	0.50	-	1.49	0.499837
Year	A.D.	0.0183	<0.0001	-	-	-	-	-	-
Prefecture number	1 to 47	0.0004	<0.0001	-	-	-	-	-	-

Table 2. Multivariate analysis with sequential adjustment, according to several time periods

All births	1980-1984 (early period)			1985-1989			1990-1994		
Yearly effect	Birth weight (g)	Standard error	r2	Birth weight (g)	Standard error	r2	Birth weight (g)	Standard error	r2
Crude	-3.98	0.11	0.0002	-8.50	0.12	0.0007	-8.71	0.13	0.0008
Adjusted for gestational age	-0.07	0.10	0.2151	-3.60	0.10	0.2483	-7.58	0.11	0.2843
Plus sex	0.02	0.10	0.2289	-3.53	0.10	0.2628	-7.57	0.10	0.2991
Plus pregnancy number	-0.19	0.10	0.2441	-3.42	0.10	0.2805	-6.32	0.10	0.3184
Plus plurality	-0.32	0.10	0.2607	-3.42	0.10	0.2948	-5.97	0.10	0.3326
Plus delivery number	-0.33	0.10	0.2607	-3.47	0.10	0.2948	-5.97	0.10	0.3226
Plus father age	-0.53	0.10	0.2592	-3.66	0.10	0.2936	-5.99	0.10	0.3316

Table 2 (continued). Multivariate analysis with sequential adjustment, according to several time periods

All births	1995-1999			2000-2004 (late period)			1980-2004 (total period)		
Yearly effect	Birth weight (g)	Standard error	r2	Birth weight (g)	Standard error	r2	Birth weight (g)	Standard error	r2
Crude	-7.66	0.13	0.0006	-4.84	0.13	0.0002	-8.07	0.01	0.0175
Adjusted for gestational age	-7.01	0.10	0.3150	-3.04	0.10	0.3456	-5.63	0.01	0.2872
Plus sex	-7.02	0.10	0.3302	-2.99	0.10	0.3607	-5.60	0.01	0.3015
Plus pregnancy number	-6.42	0.10	0.3480	-2.96	0.10	0.3754	-5.16	0.01	0.3180
Plus plurality	-6.28	0.10	0.3621	-2.79	0.10	0.3884	-5.06	0.01	0.3327
Plus delivery number	-6.28	0.10	0.3621	-2.79	0.10	0.3884	-5.07	0.01	0.3327
Plus father age	-6.26	0.10	0.3613	-2.87	0.10	0.3872	-5.13	0.01	0.3315

All births	1995-1999	2000-2004 (late period)	1980-2004 (total period)						
Yearly effect	Birth weight (g)	Standard error	r2	Birth weight (g)	Standard error	r2	Birth weight (g)	Standard error	r2
Crude	-7.66	0.13	0.0006	-4.84	0.13	0.0002	-8.07	0.01	0.0175
Adjusted for gestational age	-7.01	0.10	0.3150	-3.04	0.10	0.3456	-5.63	0.01	0.2872
Plus sex	-7.02	0.10	0.3302	-2.99	0.10	0.3607	-5.60	0.01	0.3015
Plus pregnancy number	-6.42	0.10	0.3480	-2.96	0.10	0.3754	-5.16	0.01	0.3180
Plus plurality	-6.28	0.10	0.3621	-2.79	0.10	0.3884	-5.06	0.01	0.3327
Plus delivery number	-6.28	0.10	0.3621	-2.79	0.10	0.3884	-5.07	0.01	0.3327
Plus father age	-6.26	0.10	0.3613	-2.87	0.10	0.3872	-5.13	0.01	0.3315

Figures

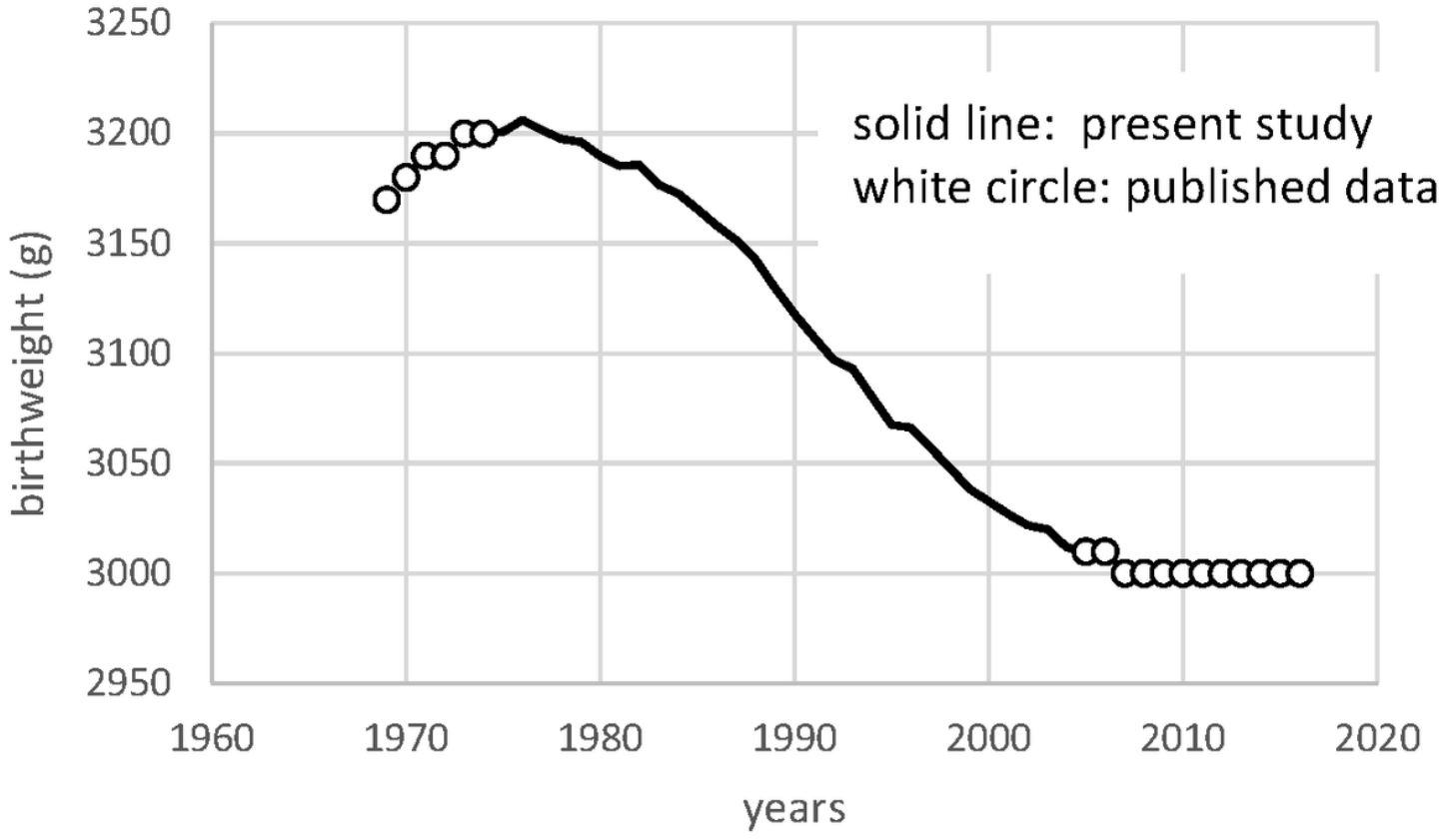

Figure 1

Secular trend of mean birthweight Published data is from Annual report of vital statistics of Japan (reference 1)

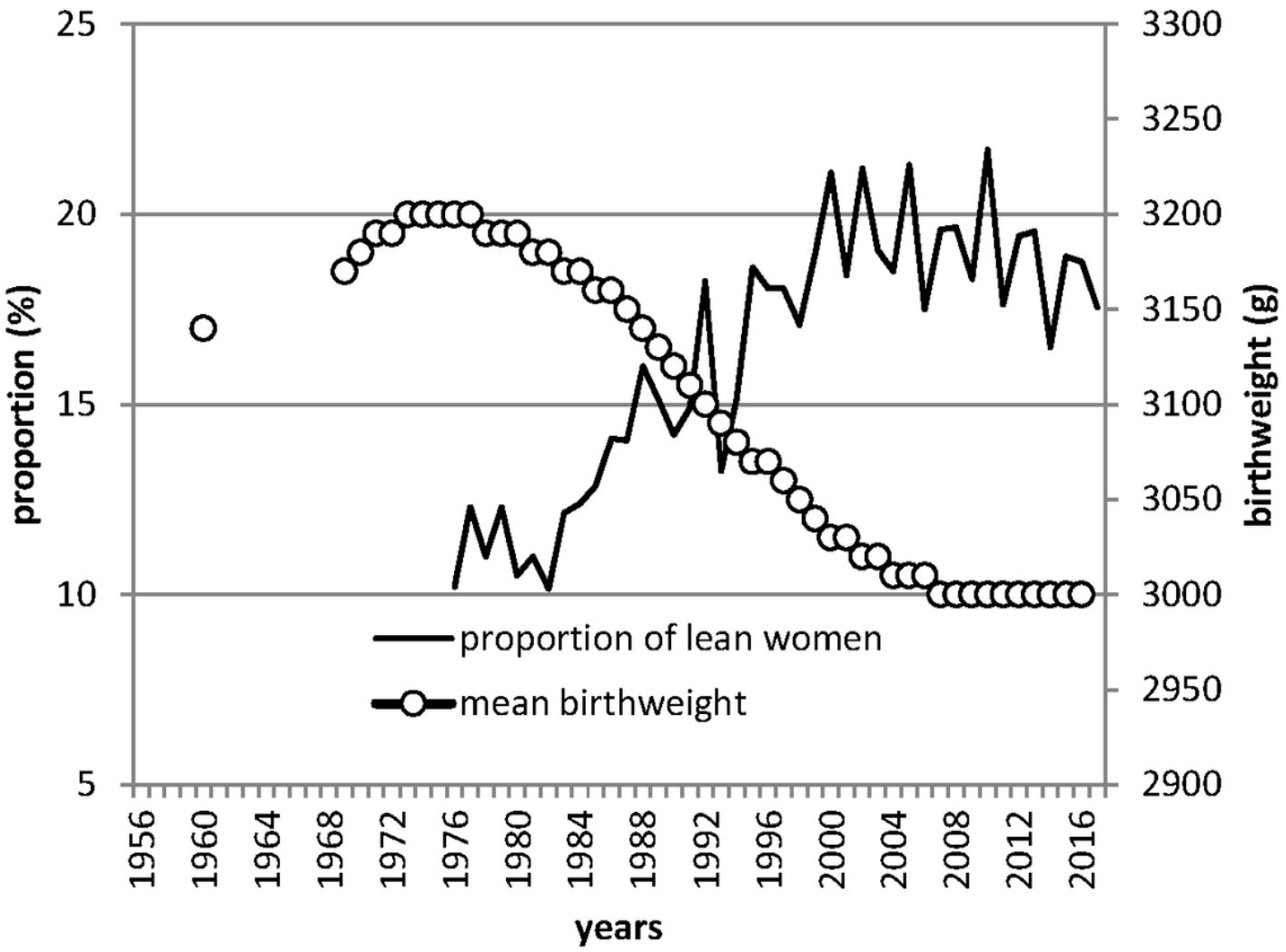

Figure 2

Secular trends of proportion of lean women and mean birthweight Mean birthweight is from Annual report of vital statistics of Japan (reference 1) Proportion lean woman means proportion of woman under BMI of 18.5 aged between 20 to 39 years, which are calculated from Annual Report of Health and Nutrition (reference 32)

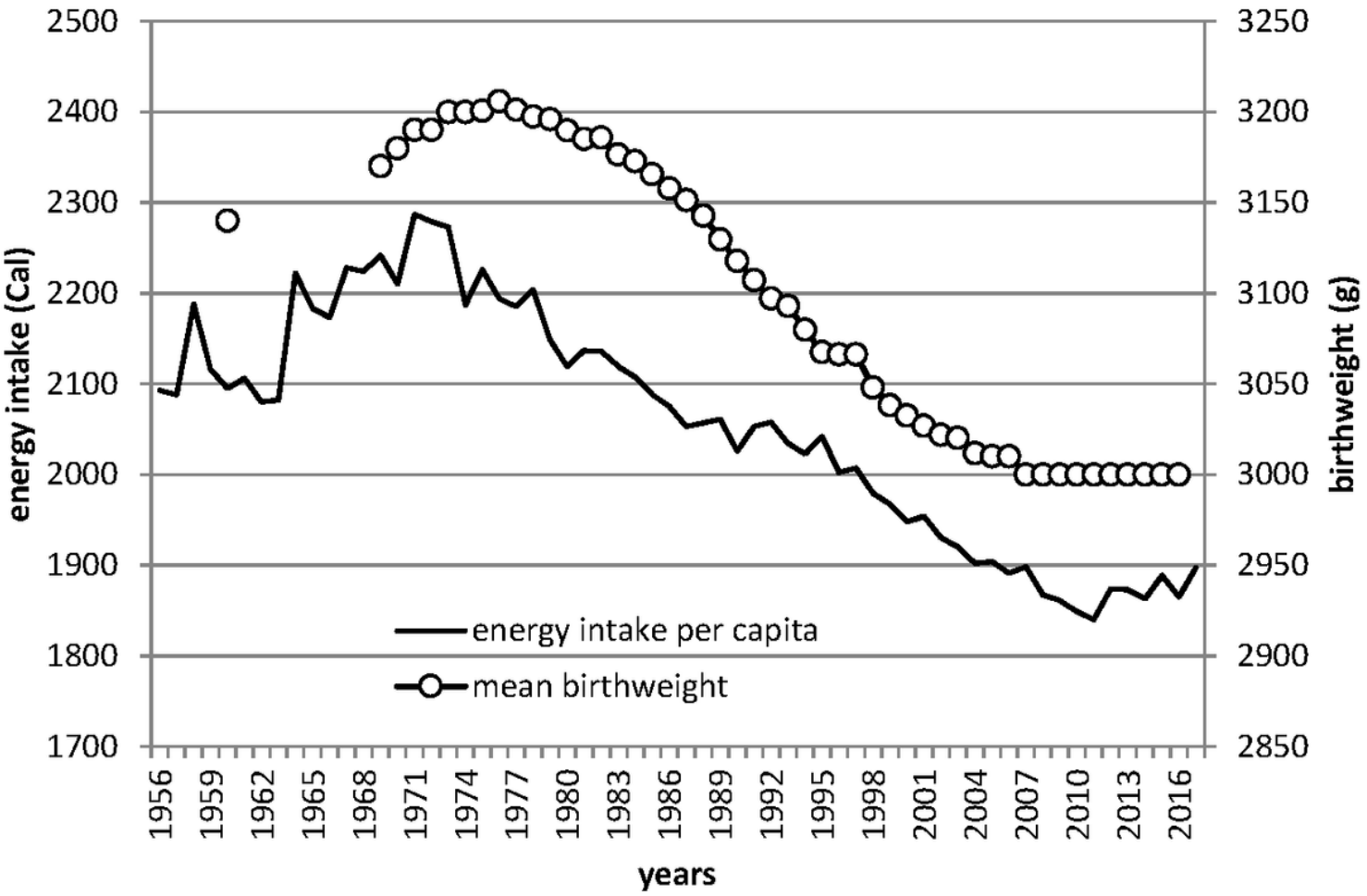

Figure 3

Secular trends of calorie intake per capita (both male and female) and mean birthweight Mean birthweight is from Annual report of vital statistics of Japan (reference 1) Calorie intake per capita is from Annual Report of Health and Nutrition (reference 32)